Industrial Waste Diversion Program

RECYCLING OF FLEXIBLE PVC WASTE

JUNE 1991

Ontario
Environment
Environnement

ISBN 0-7729-8107-8

INDUSTRIAL WASTE DIVERSION PROGRAM

Recycling of Flexible PVC Waste

Report prepared for :

Waste Management Branch
Ontario Ministry of the Environment

JUNE 1991

Cette publication technique
n'est disponible qu'en anglais.

Copyright: Queen's Printer for Ontario, 1991
This publication may be reproduced for non-commercial purposes
with appropriate attribution

PIBS 1565

92-00122/

RECYCLING OF FLEXIBLE PVC WASTE

Report prepared for:

Waste Management Branch
Ontario Ministry of the Environment

In consultation with

Ortech International

Report prepared by:

Frederick Law
Plastics Technology
Polymer Technologies Centre

DISCLAIMER

This report was prepared for the Ontario Ministry of the Environment as part of a ministry-funded project. The views and ideas expressed in this report are those of the authors and do not necessarily reflect the views and policies of the Ministry of the Environment, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

TABLE OF CONTENTS

		Page
EXECUTIVE SUMMARY		1
1.	INTRODUCTION	2
2	EXPERIMENTAL AND RESULTS	2
2.1	Sourcing and Characterization of Waste	2
2.2	Processability Study of the Wastes	3
2.3	Evaluation of the Waste Products	4
2.4	Product Design	10
2.5	Moulding of Prototypes	11
3.	CONCLUSION	12

APPENDIX A: Sourcing of PVC Coated Trim Scrap
APPENDIX B: Evaluation of the Waste Product
APPENDIX C: Product Design
APPENDIX D: Moulding of Prototypes

EXECUTIVE SUMMARY

Canadian General Tower (CGT) disposes more than two million pounds of vinyl waste per year from their main product lines. Because of the increasing annual landfill cost , CGT asked ORTECH International to investigate the potential for recycling of that waste.

The PVC waste sourced from the three plants in Ontario was analysed and characterized. It was found that the material could be compounded on a Banbury mixer and compression or injection molded.

Interlocking floor tiles were designed as a representative product to be produced from the waste. These tiles consist of mixed PVC waste backing with a thin, coloured virgin PVC surface overlay. Samples of these tiles were compression molded.

1. INTRODUCTION

A programme was established by ORTECH to convert PVC waste into a floor tile.

The following tasks have been completed and are documented in detail in subsequent sections.

(1) Sourcing and characterization of waste;
(2) Processability study of the waste products;
(3) Evaluation of the waste products;
(4) Design of floor tile;
(5) Moulding and prototyping

2. EXPERIMENTAL AND RESULTS

2.1 Sourcing and Characterization of Waste

According to the information given by Canadian General Tower, the total PVC coated trim scrap generated annually is approximately 2.2 million pounds. This waste is generated in the three plants in Ontario and can be broken down to three main categories: car trim (expanded backing type, car trim (non-expanded backing type), and wall covering. A detailed break-down of the waste is listed in Appendix A.

Based on the information provided by CGT, a composition of a representative sample was established. A blend of PVC waste (expanded car trim, non-expanded car trim M2F126, and wall covering, in proportions of 30%, 30%, and 40% respectively), which represents the overall waste generated, was tested for processability, mechanical and physical properties.

The mixture of PVC and plasticizer of the four types of wall covering and two types of car trims were determined quantitatively by extraction technique by the polymer chemistry laboratory at ORTECH International . The average PVC plus plasticizer contents of the wall coverings was 62.98%, the expanded car trim was 64.50% and the non-expanded car trim (M2F126) was 69.8%. See Reports #PC 226-90-8 and PC 226-90-9 (Appendix A) for detailed extraction method and result.

The ash contents (remaining residue after a sample was burned for four hours at 700°C) was also determined: the wall covering (China Silk, Type I) was 13.6%, the non-expanded car trim (M2F126) was 9.6% and the expanded was 9.9%. See Report # PC 226-90-9 (Appendix A) for detailed experimental method.

2.2 Processability Study of the Waste

Mixed PVC waste has been successfully processed b

- mixing in a Banbury mixer followed by compression molding;
- shredding, dry blending and compression molding;
- shredding, dry blending and injection molding;

Due to the high fibre content (up to 40%) and possibly the presence of non-expanded blowing agent, the waste material could not be successfully extruded.

A preliminary study of the extrudability of the samples showed that they lacked melt strength, and no acceptable sample was produced. The compounding of the above sample with a Banbury mixer was successful, and a homogeneous blend was obtained.

2.3 Evaluation of the Waste Products

2.3.1 Preliminarily Study of the Mechanical Properties of the Waste Products

The tensile strength, elongation at break, and hardness of each individual ingredient (expanded car trim, non-expanded car trim, and wall covering) were evaluated.

The specimens were prepared by either:

- dry blending or
- mixing on a small Brabender mixer at 60 rpm, and 170°C for 4-5 minutes

followed by:

- compression molding at 170°C for 17 minutes and
- cooling under pressure at room temperature.

The mechanical properties are shown below:

In general, the tensile strength of the unmixed samples were higher than the Brabender mixed samples; however, the elongation at break of the mixed samples were somewhat higher. We speculated that the higher tensile strength of the unmixed samples was attributed to the continuous fibre-network, which has been broken down by the intensive shearing by the Brabender mixer. Higher elongation at break of those mixed samples were probably due to better wetting after mixing.

2.3.2 Selection of Optimum Processing Aids for the Representative Sample.

The representative sample (i.e. expanded/non-expanded car trim/wall covering, 30/30/40%) was evaluated thoroughly in this Section.

Three batches (1100 grams/batch) of the representative sample were prepared with a 1.5 litre Banbury mixer, equipped with steam heating. All batches contained carbon black to give a consistent grey tone. These batches had metallic stearates, and/or wax to improve dispersion and lubrication.

The three formulations are listed as follows:

	Batches (PHR)		
	#P128	#P129	#P130
Wall covering (Type II)	37.5	37.5	39.0
Car trim (Non-expanded, M2F126)	30.0	30.0	30.0
Car trim (Expanded)	30.0	30.0	30.0
Carbon black (Degussa lamp black)	1.0	1.0	1.0
Zinc stearate (Fisher, Z-65)	1.0	/	/
Calcium stearate (Witco, SG superfine)	/	1.0	/
Wax (Kodak E43)	0.5	0.5	/

The PVC wastes were mixed thoroughly in a Banbury mixer at a speed of 250 rpm until the temperature reached 160°C prior to adding the other ingredients. The samples were further mixed for 5 minutes at a temperature not exceeding 170°C by adjusting the speed of the mixing blades.

The well mixed samples were then compression moulded to plaques of 8 inch by 8 inch x 1/4 inch.

The molding conditions were:

- temperature : 160°C
- time : 15 minutes
- cooling : 15 minutes at room temperature

The test specimens were die cut from these plaques.

The results are listed in Tables III, and IV in Appendix B.

The table below gives a summary of the mechanical tests:

	Batches		
	P128	**P129**	**P130**
Average tensile strength in Psi, (ASTM D638)	1559	2065	548
Average elongation @ br. in %, (ASTM D638)	30.3	36.7	38.6
Average Flexural strength in Psi, (ASTM D638)	993	919	665

Both the tensile strength and elongation at break of Batch P129 were the highest, except the elongation at break of Batch P130. The flexural strength of this batch is somewhat between Batches P128 and P130. Therefore, we concluded that the fibres of the PVC waste was wetted out and dispersed better with calcium stearate and wax.

2.3.3 Properties of samples

Based on the test results of the three batches described in the previous section, Batch #129 was selected for further testing.

A series of tests were conducted and the results are summarized as follows: (refer to Appendix B for detailed method and results).

The specimens were compression moulded as described in the Section 2.3.2.

1) Tensile test, ASTM D638
   tensile strength at break: 2065 Psi
   elongation at break: 36.7%

2) Flexural strength, ASTM D790
flexural strength: 919 Psi

3) Izod impact strength, ASTM D256
impact strength with notch: 7.13 ft-lb/in
impact strength without notch: 18.6 ft-lb/in

4) Brittleness temperature, ASTM D4060
Fifty percent confidence failure temperature (F50) was -1°C

Because of the high impact speed that was applied in this test, the sample responded somewhat brittle. This does not necessarily mean that the material cannot be used at a lower temperature. In fact, we have conditioned the sample at -20°C for 24 hours and flexed it by hand; no crack was noticed.

5) Hardness, ASTM D2240
Average shore "A" hardness: 88.6

6) Specific gravity, ASTM D792
A Wallace S.G. balance was used:
average S.G.: 1.353 g/c.c.

7) Water absorption, ASTM D570
Specimens were immersed in water at 23°C for 24 hours.
average weight gain of the specimens was 0.2%

8) Taber abrasion resistance, ASTM D4060
Taber 5150 abrader, H18 wheels at 1000 grams weight was used,
average weight loss: 0.299 grams

Comparison with a Lansing Buildall #6710164 floor tile, Model #2364, a 12" X 12" urethane no-wax finished 1.5 mm thick vinyl with backing tile, was also made. The same testing conditions were used and the average weight loss was 0.405 grams.

9) Compressive creep test, ORTECH setup

An indentation of 0.15 mm was recorded. A pressure of 10 Psi was applied to the specimen through a 0.56" diameter stylus at 60°C for more than 7 days. See Photo 1(Appendix B) for setup This is an accelerated test to simulate a dinner table sitting on floor tiles.

10) Flammability tests:

Smoke generation in single flaming mode and 2 ft. tunnel flame spread tests were conducted. See Report #FTS 78-16-90-51 in Appendix B for graphs and detailed results.

Smoke generation in flaming Mode, ASTM E662:

Maximum specific optical density (Dm) : >792

Flame spread tested with a two foot tunnel: Maximum flame spread (in): 9.5

The flame spread rating equivalent to a 25-ft tunnel furnace (which complies with CAN/ULC-S102.2-M88,Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies), was "80" (see Report #FTS 78-16-90-51 for correlation between 2-foot and 25-foot tunnel).

According to the "National Building Code of Canada 1990, Section 3.1.12.", Flame-Spread Rating (FSR) and Smoke Developed (SD) Classification, Table 3.1.13.B, that for floor surface of corridors not within suites for building higher than three stories, the minimum requirement for flame spreading shall not exceed 300, and the flame spread rating shall not exceed 500.

In addition, there are no FSR and SD limit for floor surfaces in other location, such as residential, except which are listed in the Table 3.1.13.B of Appendix B.

11) Carbon arc Weather-Ometer test, ASTM G23 Type D

The experimental method and result is described in detail in ORTECH's Paints & Coatings report No. P&C 38-90-69-30992-98 in Appendix B.

The following samples have been exposed in the Weather-OMeter for 168 hours:

(1) Batch #129
(2) Batch #129 but without carbon black
(3) Batch #129 with a yellow PVC overlay.

There were no visible change of appearance after the test.

12) Fungal resistance, ORTECH Method

The method used is similar to ASTM G21 except the temperature was kept constant.

The experimental method and result is described in detail in ORTECH's report No. 90-48-35000-039 in Appendix B.

The sample was rated "2" according to ASTM G-21 rating scheme ("1" rating being the least affected by fungus and "4" being the highest rating).

The sample supported fungal growth on all of the cut edge surfaces and in patches near the cut edge of the specimen. We speculated that the exposure of cotton fibres at the die-cut edge supported fungal growth rather than the PVC resin itself.

2.4 Product Design

Following consideration of potentially suitable products manufactured using the recycled material, a floor tile for outdoor use was selected for prototyping

Investigation of existing floor tiles showed different designs of injection moulded, interlocking tile. These included a multiple 'dove tail' interlocking tile from Scan-Lock in Denmark (see copy of 'Design Week' article appended) and a multiple press stud type fit from R.A. Morrison Industries Inc., a Canadian company (see Appendix C).

Initially it was thought that the proposed tile would be manufactured by calendering and die cutting, and was designed accordingly. In production, if compression moulding or injection moulding processes are used further design features could be incorporated.

Presented are prototype samples of a design of exterior interlocking tile. It is envisaged that the tile would be suitable for such uses as;

- swimming pool surrounds;
- patio flooring;
- exterior pathways;
- jetty/dock surfacing

The tiles were produced to the specification presented in the concept design perspective drawing numbers 0102 & 1040.

Features of the design include:

- datum unit tile dimension of 10 inches square by 1/4 inch thick (dimensions may differ in production);
- Interlocking edge profile;

- raised, non-slip, textured surface;
- integrally moulded, coloured, surface finish laminate;
- edge finishing strip (not prototyped).

Also presented are drawings number 0117-0119 of the compression mould tool from which the prototype samples were produced and the die cutting tool profile drawing number 0120. See also attached photographs.2 and 5 of Appendix D.

2.5 Moulding of Prototypes

The representative sample Batch #129 described in Section 2.3.2 was used for preparation of prototypes of floor tiles (see Photographs in Appendix D).

Samples of the tiles were prepared in the following sequence:

- waste vinyl was compounded in a Banbury mixer;
- the mix was placed in a compression mold and preheated to 160°C (see Photo 2);
- the mold was closed and a sample pressed for 15 minutes at 160°C;
- the sample was cooled under pressure for 15 minutes (see Photo 3);
- the mold was opened and a thin (six gauge) PVC film was placed on the top (see Photo 4);
- the mold was closed, pressure applied and only a top plate heated to 160°C for 15 minutes to fuse the overlay;
- the mold was cooled under pressure;
- the mold was opened and the sample removed
- the tile was die cut to its shape (see Figure 5).

4 CONCLUSION

- The waste materials could be processed with most processing techniques except extrusion.

- Processing aids were found useful to enhance the mechanical properties of the waste product.

- Both the mechanical and flammability tests confirmed that there are no reasons the waste product cannot be used as a floor tile (both indoor and outdoor).

- The process options for the manufacturing of tiles appear to be as follows:
  (i) produce tiles by mixing on a Banbury mixer followed by injection molding (black tiles only)
  (ii) as in (i), but modify injection mold to allow for the incorporation of a coloured PVC sheet overlay.
  (iii) mix by extrusion in a Gelimat, discharge melt into compression mold with an overlay positioned in it, close the mold and produce the tile.
  (iv) same as in (iii), but use large molds (for example panels for 9 tiles each), die cut individual tiles after molding.

Frederick Law, M.Sc.
Project Scientist
Plastics Technology

J. Leidner, M.A.Sc., P. Eng.
Manager
Polymer Technologies Centre

APPENDIX A: Sourcing of PVC Coated Trim Scrap
(9 pages)

TABLE 1

CANADIAN GENERAL TOWER LIMITED
PVC COATED TRIM SCRAP

PLANT LOCATION	TYPE	POUND PER YEAR	PERCENTAGE	SUB-TOTAL
CAMBRIDGE	M2F126	166500	7.38%	
	M2F125	43200	1.91%	
	M2F132	36700	1.63%	
	M2F128	27500	1.22%	
	M2F150	44000	1.95%	17.10%
	NON WOVEN	22000	0.98%	
	THOMAS BUS	20000	0.89%	
	4K FELT	12000	0.53%	
	FOAM LAMINATE	14000	0.62%	
	NYLON SCRIM			
	OSNABURG			
TORONTO	EXPANDED	697000	30.89%	
	FELT	119000	5.27%	
	JERSEY	74000	3.28%	41.28%
	9315 JAYCLOTH	41500	1.84%	
OAKVILLE	TYPE II 20 OZ	176000	7.80%	
	TYPE I 15 OZ	140000	6.20%	
	TYPE I 12 OZ	101000	4.48%	
	TYPE II 24 OZ	22000	0.98%	
	ROLL GOODS (MIXTURE OF TYPE I&II)	500000	22.16%	41.61%
CORPORATE TOTAL (POUNDS)=		2256400	100.00%	

July 23, 1990

Fred Law
Plastics Technology

REPORT NUMBER: PC 226-90-8

IDENTIFICATION: W.O. #6786

SPECIFICATIONS OF ORDER: Quantitative Extractions

INTRODUCTION

Four samples of vinyl wall coverings were submitted for quantitative extractions to determine the combined weight percent of PVC and plasticizer. The samples were labelled:

ORTECH #

9068F0011 - Hunter Code 48302
9068F0012 - Apricot Code 43745
9068F0013 - Jasper Code 45179
9068F0014 - Apricot Code 44084

We, ORTECH Corporation, conducting business as "ORTECH International", stipulate that this document is subject to the following terms and conditions:
1. Any proposal contained herein was prepared for the consideration of the addressee only. Its contents may not be used by nor disclosed to any other party without our prior written consent.
2. Any testing, inspection or investigation performed by us will be conducted in accordance with normal professional standards. Neither we nor our employees shall be responsible for any loss or damage resulting directly or indirectly from any default, error or omission.
3. Any report, proposal or quotation prepared by us refers only to the particular material, instrument or other subject referred to in it. No representation is made that similar articles will be of like quality.
4. No report issued by us shall be published in whole or in part without our prior written consent.
5. Our name shall not be used in any way in connection with the sale, offer or advertisement of any article, process or service.
6. We reserve the right not to commence and/or continue any work until payment arrangements satisfactory to us are established.

EXPERIMENTAL

The samples (approximately 1 g) were cut up and placed in approximately 40 mLs of tetrahydrofuran (THF) for 2 days.

The THF insolubles were centrifuged out of solution and further washed and centrifuged.

The insolubles were dried and weighed.

RESULTS

The amount of filler and booking material (THF insolubles) was quantitatively determined by extraction.

The combined amount of PVC and plasticizer was then determined by subtracting the above amount from 100%.

The analysis was performed in duplicate. Table I summarizes the results.

for J. E. Farr
Project Technologist
Polymer Chemistry

Uri Law, Ph.D.
Project Scientist
Polymer Chemistry

Read & Approved by:

T. Kilp, Ph.D.
Section Manager
Polymer Chemistry & Microscopy

TABLE I

Extraction Results

Sample	% Filler & Backing	% PVC & Plasticizer
9068F0011	38.2	61.8
	38.5	61.5
	Average: 38.4	**Average: 61.6**
9068F0012	40.3	59.7
	39.3	60.7
	Average: 39.8	**Average: 60.2**
9068F0013	35.0	65.0
	35.2	64.8
	Average: 35.1	**Average: 64.9**
9068F0014	34.8	65.2
	34.8	65.2
	Average: 34.8	**65.2**

July 31, 1990

F. Law
Plastics Technology

REPORT NUMBER: PC 226-90-9

IDENTIFICATION: W.O. #8594

SPECIFICATIONS OF ORDER: Ash Content and Extractables

INTRODUCTION

Three samples were received for analysis to determine the ash content and the extractables. The samples were labelled;

China silk wall covering (9068F0014), TYPE I
M2F126 (9068F0015)
Expanded (9068F0016)

We, ORTECH Corporation, conducting business as "ORTECH International", stipulate that this document is subject to the following terms and conditions:
1. Any proposal contained herein was prepared for the consideration of the addressee only. Its contents may not be used by nor disclosed to any other party without our prior written consent.
2. Any testing, inspection or investigation performed by us will be conducted in accordance with normal professional standards. Neither we nor our employees shall be responsible for any loss or damage resulting directly or indirectly from any default, error or omission.
3. Any report, proposal or quotation prepared by us refers only to the particular material, instrument or other subject referred to in it. No representation is made that similar articles will be of like quality.
4. No report issued by us shall be published in whole or in part without our prior written consent.
5. Our name shall not be used in any way in connection with the sale, offer or advertisement of any article, process or service.
6. We reserve the right not to commence and/or continue any work until payment arrangements satisfactory to us are established.

EXPERIMENTAL

The ash content was determined for all three samples. Approximately 0.5 grams was weighed out in duplicate for each sample. The crucibles were conditioned in the muffle furnace at 700°C for 1/2 hour and then cooled in the desiccator for one hour and weighed. The samples were placed into the conditioned crucibles and ashed in the muffle furnace at 700°C for four hours. The crucibles were placed into the desiccator and cooled for one hour before weighing.

The percent extractables was determined for samples 9068F0015 and 9068F0016. The samples (approximately 1 gm) were cut up and placed into approximately 40 mLs of tetrahydrofuran (THF) overnight.

The THF insolubles were centrifuged out of solution and further washed and centrifuged.

The insolubles were dried and weighed.

RESULTS

The percent ash results are shown in Table I "Percent Ash".

The amount of THF insolubles was quantitatively determined by extraction.

The extractables was then determined by subtracting the above amount from 100%.

The analysis was performed in duplicate. Table II "Percent Extractables" summarizes the results.

S. V. Hannah
Project Technologist
Polymer Chemistry

Uri Law, Ph.D.
Project Scientist
Polymer Chemistry

Read & Approved by:

T. Kilp, Ph.D.
Section Manager
Polymer Chemistry & Microscopy

TABLE I

Percent Ash

Sample		Percent Ash
9068F0014 (CHINA SILK, TYPE 1)	#1	19.6
	#2	19.5
	Average	19.6
9068F0015 (M2F126)	#1	9.4
	#2	9.7
	Average	9.6
9068F0016 (Expanded)	#1	10.1
	#2	9.8
	Average	9.9

TABLE II

Percent Extractables

Sample		Percent Extractables
9068F0015 (M2F126)	#1	64.3
	#2	64.7
	Average	**64.5**
9068F0016 (EXPANDED)	#1	70.5
	#2	69.1
	Average	**69.8**

APPENDIX B: Evaluation of the Waste Product
(30 pages)

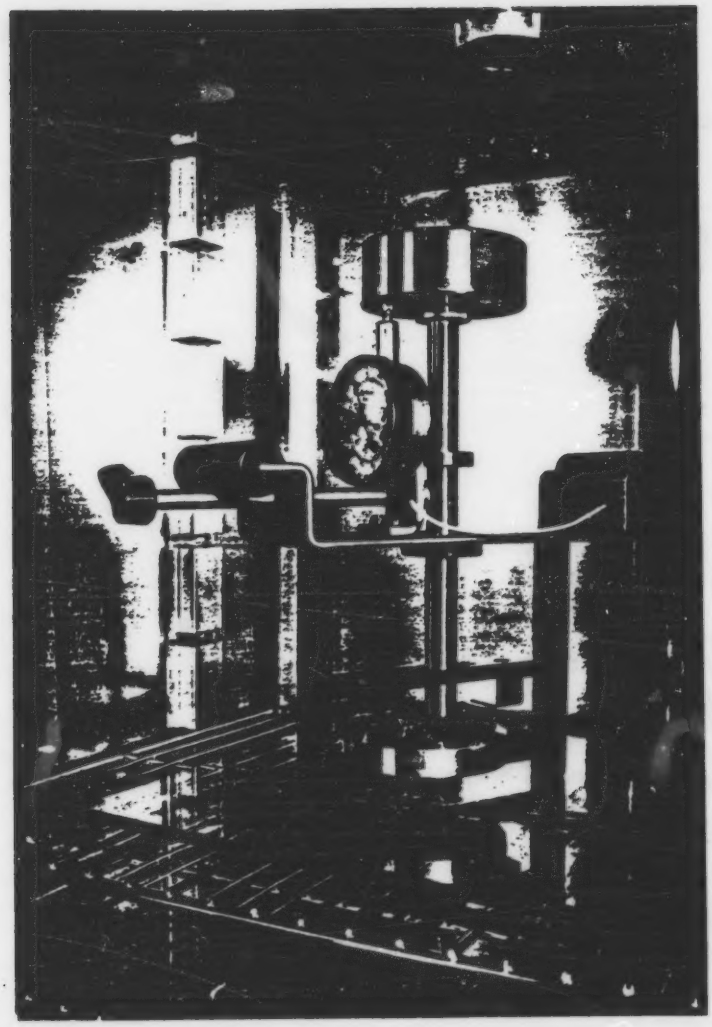


Photo 1: Set-up of Compressive Creep Test Apparatus

TABLE

TENSILE TEST RESULT OF REPRESENTATIVE SPECIMENS MIXED IN BANBURY M IXER
ASTM D638

SPECIMEN NO.	SAMPLE DESCRIPTION	WIDTH (MM) .	THICKNESS (MM)	STRESS @ BR. (PSI)	ELONGATIO @ BR. (%)
P128A	wall cover. 37.5%	0.464	0.268	1514.2	24.3
P128B	non-exp. trim 30%	0.465	0.267	1455	29.8
P128C	exp. trim 30%	0.462	0.268	1706.8	36.9
AVG. >>>	carbon black 1% Zinc stearate 1% wax 0.5%			1558.7	30.3
P129A	wall cover. 37.5%	0.469	0.262	1915.4	31.8
P129B	non-exp. trim 30%	0.46	0.262	2083	34
P129C	exp. trim 30%	0.471	0.262	2198	44.3
AVG. >>>	carbon black 1% calcium stearate 1% wax 0.5%			2065	36.7
P130A	wall cover. 39%	0.473	0.249	1537	34.5
P130B	non-exp. trim 30%	0.469	0.246	1559	42.6
AVG. >>>	exp. trim 30% carbon black 1%			1548	38.55

NOTE:
1) The wall covering tested was type I
2) The specimens tested were compression moulded

TEST CONDITIONS:

humidity:	50%
temperature:	23C
crosshead speed:	50mm/min.
full scale load:	5.00KN
gauge length:	25mm
specimen G. L. :	100mm

TABLE
TENSILE TEST RESULT OF INDIVIDUAL AND MIXTURE OF PVC SCRAP
ASTM D638

SPECIMEN NO.	SAMPLE DESCRIPTION	WIDTH (MM)	THICKNESS (MM)	STRESS @ BR. (PSI)	YOUNG.S MODULUS (PSI)	ELONG. @ BR. (%)
1A	Brabender mixed exp. trim/wall cover. 60/40%	12.6	3.23	959	3983	24
2A	hand mixed	12.64	6.67	929	3716	25
2B	exp. trim 60% wall cover. 40%	12.7	6.63	976	9520	27.9
3A	Brabender mixed	12.6	6.31	986	10200	19.2
3B	exp. trim 50.7% wall cover. 33.8% CaCO3 15.2% stearic acid 0.25%	12.6	6.32	912	11500	10.97
4A	expanded car	12.6	6.32	759	3480	57.6
4B	trim as is	12.5	6.69	721	2470	58.2
5A	Brabender mixed	12.57	6.48	712	3360	21.2
5B	exp. trim 30% non-exp. trim (M2F126) 30% wall cover. 40%	12.7	6.24	1150	12500	27.12
6A	Brabender mixed	12.64	7.05	586	2486	76.7
6B	exp. trim as is	12.6	7.03	624	2790	73.75
7A	Brabender mixed	12.6	6.19	1370	28500	17.37
7B	wall covering as is	12.6	6.17	1110	35500	6.7
8A	wall covering	12.7	6.13	2180	31700	12.5
8B	as is	12.7	6.15	1920	27300	8.53

NOTE:
1) The wall covering tested was type I
2) The specimens tested were compression moulded

TEST CONDITIONS:

humidity:	50%
temperature:	23C
crosshead speed:	50mm/min.
full scale load:	5.00KN
gauge length:	25mm
specimen G. L. :	100mm

TABLE II
MECHANICAL PROPERTIES OF THE PVC WASTE FOR CGT

sample description (all samples were compression moulded)	specimen number	stress @ break (psi)	elongation @ break (%)	hardness (shore A)
Brabender mixed: 60% expanded car trim 40% Type II wall covering	#1-1	959	24	90 (average)
dry blended: 60% expanded car trim 40% Type II wall covering	#2-1 #2-2	929 976	25 27.9	89.2 (average)
Brabender mixed: 50.7% expanded car trim 33.8% Type II wall covering 15.2% calcium carbonate 0.25% ctearic acid	#3-1 #3-2	986 912	19.2 11	85 (average)
expanded car trim (tested as is)	#4-1 #4-2	759 721	57.6 58.2	83.4 (average)
Brabender mixed: 30% expanded car trim 30% M2F126 car trim 40% Type II wall covering	#5-1 #5-2	712 1150	21.2 27.1	87.6 (average)
Brabender mixed: expanded car trim	#6-1 #6-2	586 624	76.7 73.8	78.2 (average)
Brabender mixed: Type II wall covering	#7-1 #7-2	1370 1110	17.3 6.7	22 (average, Shore 'D')
Type II wall covering (tested as is)	#8-1 #8-2	2180 1920	12.5 8.53	21.8 (average Shore 'D')

The tensile tests were conducted in according with the ASTM D628 method under the following conditions:

1) Humidity: 50%
2) Temperature (deg. C): 23
3) Cross head speed (mm/min): 50.00
4) Full scale load range (KN): 5.000
5) Typical dimension of a specimen (mm): 127.0 X 75.0 X 6.0

(91)

July 23.90

Hardness.

Sample I.D	Hardness.	Average
1. Car Interior Trim (E) As is	Shore A. 85. 84, 80, 83. 85.	83.4
2. Wall Covering (D) As is	Shore D 22, 22, 21, 22, 22.	21.8
3. Car Interior Wall Covering As is 6/4	Shore A 92, 89, 89, 88, 88	89.2
4. Car Interior Trim (C) barbender	Shore A 75, 80. 78, 80, 78	78.2
5. Wall Covering (D) barbender	Shore D 22, 23, 22, 21, 22	22.0
6 Car Interior by Wall Covering 60 barbender	Shore A 89. 90, 90, 91. 90	90.0
7. Car Interior Trim (B) As is	Shore A 88, 87, 88, 85, 89	87.4

PVC. recycle

TABLE 4

August 30,

3 point Flexural strength

$= 3PL/2bd^2$

where

P = load ~~psi~~ (lbf)
L = support span (in)
b = width of beam in.
d = deth of beam in.

	P (lbs)	L (in)	b (in)	d (in)	Flexural str (psi)
P128A batch 1	4.72	4	0.451	0.262	914.8
P128B (1)	4.38	4	0.452	0.260	860.1
P128A (2)	6.18	4	0.453	0.269	1131.2
P128B (2)	5.84	4	0.453	0.269	1069.0
P129A	4.72	4	0.452	0.262	912.8
P129B	4.83	4	0.453	0.263	924.9
P130A	3.21	4	0.451	0.244	717.3
P130B	2.77	4	0452	0.245	612.6

(61

IZOD IMPACT (ASTM D256)

Sept. 14, 90

NOTCHED

Specimen	WIDTH	FT. POUNDS	FT·POUNDS/IN.
1	0.243 in.	1.62	6.67
2	0.251	1.93	7.69
3	0.239	1.59	6.65
4	0.240	1.82	7.58
5	0.238	1.79	7.52
6	0238	1.66	6.97
7	0.240	1.79	7.46
8	0.244	1.89	7.75
9	0.242	1.63	6.74
10	0.239	1.50	6.28

Average 7.13

UNNOTCHED (N.B.)

1	0.242	4.71	19.5
2	0.239	4.40	18.4
3	0.247	4.48	18.1
4	0.241	4.60	19.1
5	0.248	4.70	18.9
6	0.240	4.40	18.3
7	0.242	4.39	18.1
8	0.240	4.20	17.5
9	0.241	4.80	19.9
10	0.242	4.30	17.8

Average 18.6

C.G.T.

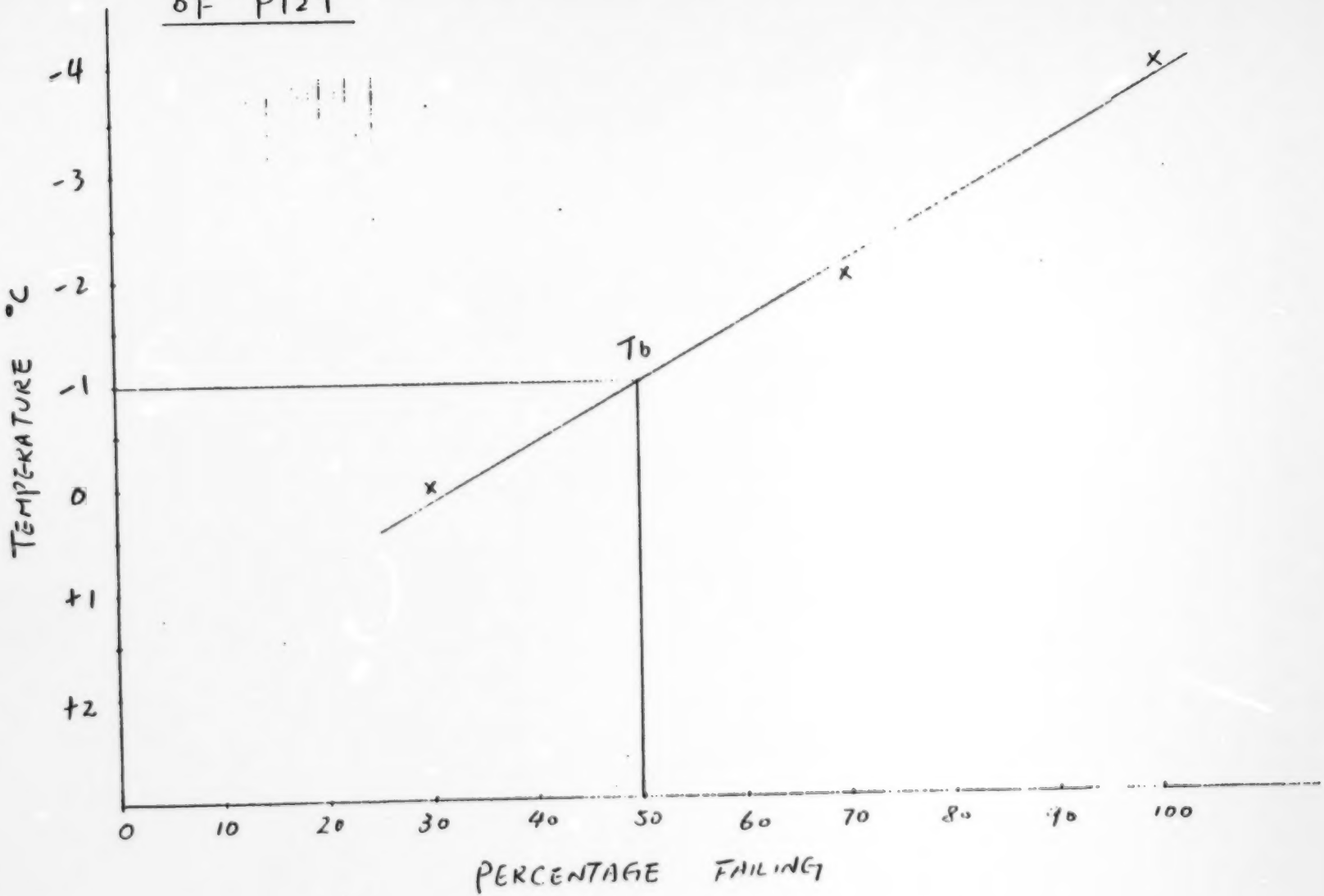
Brittleness Temperature of P129

specimen thickness = 2.01mm.

Test Method : ASTM D746

Temperature
+1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
-18
-19
-20
-21
-22
-23
-24
-25
-26
-27
-28
-29
-30

GRAPHIC METHOD FOR DETERMINING THE BRITTLENESS TEMPERATURE Tb OF P129



Vol-
0301

ASTM
D792

Wallace Test Equipment.
S.G. Balance

PROCEDURE

1. Fill the glass beaker with distilled water.

2. Fit the needle and sinker to beam.

3. With the sliding weights at the bottom of the long arm, adjust the level screw until the pointer reads 1.00 accurately.

4. Remove the needle from the arm and impale the test piece on same. For hard materials, it may be found helpful to make a small nick with a razor blade to take the needle point. However, this should be avoided whenever possible, as air bubbles may be trapped in the cut, affecting readings slightly.

5. Replace needle, with test piece, on beam.

6. Adjust the sliding weight on the long arm, first with the major weight and finally with the minor weight, until the pointer registers accurately with the mark 'A' on the back plate. Do NOT alter the position of the screw weights on the short arm.

7. Raise the beam to lift the test piece, and place the beaker of distilled water on the platform. Raise the platform and beaker until the test piece is immersed. The exact quantity of distilled water is not important but should be sufficient to cover the test piece completely. N.B. Ensure that the specimen does not touch the sides or bottom of the beaker, and that the sinker does not make contact with the water, during the test.

8. Gently release the arm and read the specific gravity from the scale.

NOTE

Air bubbles clinging to the test piece will cause error and may be avoided either by adding a trace of detergent to the distilled water (about 1 part in 10,000) or by dipping the test piece in ethyl alcohol or industrial methylated spirit. The "wetting agent" used must not cause swelling or similar action on the material being tested.

MAINTENANCE

The S.G. balance should be carefully handled, housed and stored. It should be kept clean and be covered when not in use. Never lubricate the bearings as this will cause inaccurate results.

SG = 1.360
1.355
1.345
3 | 4.060
AVG → 1.353

C. G. T.

H_2O Absorption in 24 hours. ASTM D 570
P 129

Specimen	Before drying at 50°C for 24 hrs.	After drying at 50°C for 24 hrs.	After immersed in H_2O at 23°C for 24 hrs.	Wat... abs...
1.	15.4010 gm	15.3870	15.4202	0.03
2.	16.1218 gm	16.1079	16.1357	0.027
3.	15.6878 gm	15.6660	15.7015	0.035
Average	15.7369	15.7203	15.7525	0.032
				or 0.20

September 26, 1990

TO: F. Law
Plastics Technology

REPORT NUMBER: P&C 38-90-69-30992

IDENTIFICATION: W.O. #2200

SPECIFICATIONS OF ORDER: Taber Abrasion of Plastic Sample

INTRODUCTION

One plastic sample (three specimens) was submitted for Taber abrasion. These specimens were labelled as follows:

Client Identification	ORTECH Sample Number
P129	90-69-C057-1
P129	90-69-C057-2
P129	90-69-C057-3

PROCEDURE

The sample was tested in accordance with ASTM D4060, Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser. Testing was done with a Taber 5150 abrader using H18 wheels with 1000 gram wheel weights for 1000 cycles.

Both tables on the abrader were used.

The specimens were weighed before and after testing and the differences reported.

RESULTS

Specimen	Total weight loss, grams
90-69-C057-1	0.3414
90-69-C057-2	0.2047
90-69-C057-3	0.3515

CONCLUSION

The average weight loss for sample P129 was 0.2992 grams.

Ron Zeeman
Project Technologist
Paints and Coatings

David M. Hacker
Manager
Coatings and Adhesives

October 10, 1990

TO: F. Law
Plastics Technology

REPORT NUMBER: P&C 38-90-69-30992-96

IDENTIFICATION: W.O. #41518

SPECIFICATIONS OF ORDER: Taber Abrasion of Floor Tile Sample

INTRODUCTION

One floor tile sample was submitted for Taber abrasion. The specimens from this sample were labelled as follows:

Client Identification	ORTECH Sample Number
Lansing Buildall 6710164	90-68-P0184-1
Lansing Buildall 6710164	90-68-P0184-2
Lansing Buildall 6710164	90-68-P0184-3

PROCEDURE

The sample was tested in accordance with ASTM D4060, Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser. Testing was done with a Taber 5150 abrader using H18 wheels with 1000 gram wheel weights for 1000 cycles.

Both tables on the abrader were used.

The specimens were weighed before and after testing and the differences reported.

RESULTS

Specimen		Total weight loss, grams
90-68-P0184-1		0.4373
90-68-P0184-2		0.3696
90-68-P0184-3		0.4065
	Average	0.4045

CONCLUSION

The average weight loss for sample Lansing Buildall 6710164 was 0.4045 grams per 1000 cycles using H18 wheels and 1000 gram wheel load.

Ron Zeiman
Project Technologist
Paints and Coatings

David M. Hacker
Manager
Coatings and Adhesives

ATTENTION: Mr. Fred Law

October 12, 1990

REPORT NUMBER: FTS 78-16-90-512

IDENTIFICATION: PVC material, 6.6 mm thick, identified as P129.
(ORTECH Sample Identification Number #90-75-S0512)

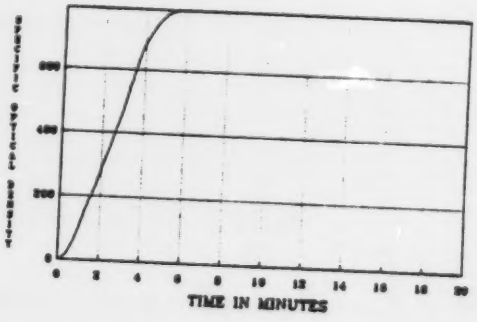
SPECIFICATIONS OF ORDER: Determine smoke generation according to ASTM E 662 in single flaming mode only, and single 2 ft. tunnel flame spread test, as per your W.O. #6785 dated September 17, 1990.

TEST RESULTS

ASTM E 662 - Flaming Mode
Specific Optical Density of Smoke
Generated by Solid Materials.

Specific Optical Density

At 1.5 minutes	$Ds_{1.5}$	:	196
At 4.0 minutes	$Ds_{4.0}$	:	689
Maximum	Dm	:	>792
Corrected Maximum	Dm(corr)	:	>792



TEST RESULTS (Cont..)

TWO FOOT TUNNEL

Maximum Flame Spread (in.)	Flame Spread Rating
9.5	80

COMMENTS

The high levels of smoke generation shown by the ASTM E 662 data are typical of polyvinyl chloride materials.

The estimated flame spread rating of 80 is an intermediate value (gypum wallboard = 15, wood panelling ≤ 150). The flame spread rating of PVC materials tends to vary according to the amount of flammable plasticizer used in the composition.

M.J. Featherstone,
Fire & Flammability,
Product Development & Evaluation Centre.

I. Smith,
Fire & Flammability,
Product Development & Evaluation Centre.

H.J. Campbell, Ph.D.,
Manager,
Fire & Flammability.

APPENDIX

ASTM E 662-83

Specific Optical Density of Smoke Generated by
Solid Materials (NBS Smoke Chamber)

This method of test covers a procedure for measuring the smoke generated by solid materials and assemblies in thickness up to and including 1 inch (25.4mm). Measurement is made of the attenuation of a light beam by smoke (suspended solid or liquid particles) accumulating within a closed chamber due to nonflaming pyrolytic decomposition and flaming combustion. Results are expressed in terms of specific optical density, which is derived from a geometrical factor and the measured optical density (absorbance).

Specimens are dried for 24 hours at 60°C and conditioned to equilibrium at 50% RH and 23°C.

Three specimens, 3" square, are exposed to each mode of combustion. The % light transmittance during the course of the combustion is recorded. These data are used to express the quantity of smoke in the form of Specific Optical Density based on the following formula which assumes the applicability of Bouguer's law:

$$Ds = (V/AL)\cdot\log(100/T) = G\cdot\log(100/T) = 132\cdot\log(100/T)$$

Where: Ds = Specific Optical Density
T = % Transmittance
V = Chamber Volume (18 ft^3)
A = Exposed Area of the Sample (0.0456 ft^2)
L = Length of Light Path in Chamber (3.0 ft)
G = Geometric Factor

Among the parameters normally reported are:

$D_{s_{1.5}}$ - specific optical density after 1.5 minutes

$D_{s_{4.0}}$ - specific optical density after 4.0 minutes

Dm - maximum specific optical density at any time during the 20 minute test

$\overline{Dm}_{(corr)}$ - Dm corrected for incidental deposits on the optical surfaces

APPENDIX

SUMMARY OF METHOD AND CALCULATIONS

The two-foot tunnel was designed to evaluate materials having flame spreads similar to, or less than, red oak. Red oak is assigned a flame spread rating of 100 on the 25-foot tunnel and it yields a maximum flame spread of 12 inches on the two-foot tunnel.

Assuming a direct correlation, the flame spread rating (FSR) is calculated as maximum flame spread times 8.3. Thus, depending upon the nature of the product under test, this FSR can be taken as an approximation to the FSR that would result from a 25-foot tunnel test.

Table 1-5 Two-foot Tunnel Test (Levy [16])

Item	Flame Spread Rating: 30°–30° Inc'd. Tunnel	Flame Spread Rating: 25-ft Tunnel	Comment
Asbestos—cement ¼ in.	0	0	No smoke (0 rating)
Cellular glass—9 pcf	3–5	5–8	No smoke
Acoustical tile—mineral type	13–16	10–15	Very little smoke
Tectum—1 in	15–20	15	Very little smoke
Phenolic foam—3.5 pcf	22	<25	Little smoke, but smolders continuously
Acoustical tile—treated cellulose	24–33	25	Little smoke
Intumescent paint	28–30	25	Low smoke
Redwood	71–78	65–80	Low smoke
Rigid vinyl foam—2 pcf	83–86	—	Surface flash and melted in 1 min
Hardboard—¼ in.	87	90–105	Very little smoke
Red oak—nom. 1 in.	100	100	Smoke (100 rating)
Birch—nom. 1 in	100–105	105–110	Smoky
Urethane—SE 2 pcf	100–109	···	Very smoky. High initial surface flash
Urethane—NB 2 pcf	102–105	···	Very smoky. High initial surface flash
Urethane—NB 2 pcf	111–116	···	Very smoky. High initial surface flash
Douglas fir plywood—¼ in.	113–127	100–169	Low smoke
Northern white pine—nom. 1 in.	145–150	165	Smoky
Epoxy foam—2.5 pcf	150+	Very large	Very smoky. Burned completely
Urethane—6.5 pcf	150+	Very large	Very smoky. High surface flash
Polystyrene—1.5 pcf	150+	Very large	Burned completely in less than 1½ min
Polystyrene FR—2 pcf	Melted when flame applied in less than 2 min, test interval		

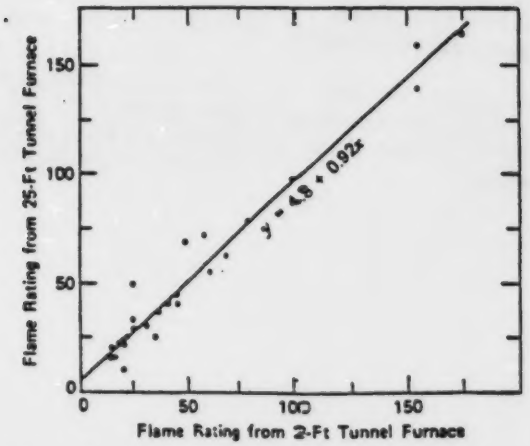


Figure 1-1 Correlation of results from 25- and 2-ft flame tunnels.

spread rating of not more than 25, and

(b) 300 m² in area with no dimension more than 20 m where the exposed construction materials within the space have a *flame-spread rating* of more than 25.

(2) Every concealed space in exterior cornices, mansard style roofs, balconies and canopies in which the exposed construction materials within the space have a *flame-spread rating* of more than 25 shall be separated by construction conforming to Article 3.1.11.7.

(a) at the points where such concealed spaces extend across the ends of required vertical *fire separations*, and

(b) so that the maximum dimension in any concealed space is not more than 20 m.

3.1.11.6. Fire Stopping of Crawl Spaces. Every unsprinklered crawl space not considered as a *basement* in Article 3.2.2.5. shall be separated by construction conforming to Article 3.1.11.7. into compartments not more than 600 m² in area with no dimension more than 30 m.

3.1.11.7. Fire Stop Materials

(1) Except as provided in Sentences (2) to (4), materials used to separate concealed spaces into compartments shall remain in place and prevent the passage of flames for a period of not less than 15 min when subjected to the standard fire exposure in CAN4-S101-M, "Standard Methods of Fire Endurance Tests of Building Construction and Materials."

(2) Gypsum board not less than 12.7 mm thick and sheet steel not less than 0.38 mm thick need not be tested in conformance with Sentence (1) provided all joints have continuous support.

(3) In *buildings* required to be of *noncombustible construction*, wood nailing elements described in Article 3.1.5.6. need not be tested in conformance with Sentence (1).

(4) In *buildings* permitted to be of *combustible construction* and in *combustible* roof systems permitted by Sentence 3.1.5.3.(2), materials used to separate concealed spaces into compartments are permitted to be

(a) solid lumber not less than 38 mm thick,

(b) phenolic bonded plywood, waferboard, or strandboard not less than 12.5 mm thick with joints supported, or

(c) 2 thicknesses of lumber each not less than 19 mm thick with joints staggered, where the width or height of the concealed space is such that more than one piece of lumber not less than 38 mm thick is necessary to block off the space.

(5) Openings through materials referred to in Sentences (1) to (4) shall be protected to maintain the integrity of the construction.

(6) Where materials referred to in Sentences (1) to (4) are penetrated by construction elements or by service equipment, fire stop materials shall be used to seal the penetration.

3.1.12. Flame-Spread Rating and Smoke Developed Classification

3.1.12.1. Determination of Ratings

(1) Except as provided in Sentences (2) and (3), the *flame-spread rating* and smoke developed classification of a material, assembly of materials or structural member shall be determined on the basis of not less than 3 tests conducted in conformance with CAN/ULC-S102-M, "Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies."

(2) The *flame-spread rating* and smoke developed classification of a material or assembly of materials shall be determined on the basis of not less than 3 tests conducted in conformance with CAN/ULC-S102.2-M, "Standard Method of Test for Surface Burning Characteristics of Flooring, Floor Covering, and Miscellaneous Materials and Assemblies," where the material or assembly of materials

(a) is designed for use in a relatively horizontal position with only its top surface exposed to air,

(b) cannot be tested in conformance with Sentence (1) without the use of supporting material that is not representative of the intended installation, or

(c) is thermoplastic.

(3) A material, assembly of materials or a structural member is permitted to be assigned a *flame-spread rating* and smoke developed classification on the basis of Chapter 2, "Fire Performance Ratings" of the Supplement to the NBC 1990.

3.1.13. Interior Finish

3.1.13.1. Interior Finish Description

(1) Interior finish material shall include any material that forms part of the interior surface of a floor, wall, *partition* or ceiling, such as

(a) interior cladding of plaster, wood or tile,
(b) surfacing of fabric, paint, plastic, veneer or wallpaper,
(c) doors, windows and trim,
(d) lighting elements such as light diffusers and lenses forming part of the finished surface of the ceiling, and
(e) carpet material that overlies a floor, when such floor is not intended as the finished floor.

3.1.13.2. Flame-Spread Rating

(1) Except as otherwise provided in this Subsection, the *flame-spread rating* of interior wall and ceiling finishes, including glazing and skylights, shall be not more than 150 and shall conform to Table 3.1.13.A.

(2) Except as permitted in Sentence (3), doors, other than those in Group A, Division 1 *occupancies*, need not conform to Sentence (1) provided they have a *flame-spread rating* of not more than 200. (See Appendix A.)

(3) Doors within *dwelling units* need not conform to Sentences (1) and (2).

(4) Where a wall or ceiling finish is required to have a *flame-spread rating* of less than 150 in Sentence (1), up to 10 per cent of the total wall area and 10 per cent of the total ceiling area is permitted to have a *flame-spread rating* of not more than 150, except that up to 25 per cent of the total wall area of lobbies described in Sentence 3.4.4.2.(2) is permitted to have a *flame-spread rating* of not more than 150.

(5) Except in the case of Group A, Division 1 *occupancies*, *combustible* doors, skylights, glazing and light diffusers and lenses shall not be considered in the calculation of wall and ceiling areas described in Sentence (4).

3.1.13.3. Bathrooms in Residential Suites.

The *flame-spread rating* of interior wall and ceiling finishes for bathrooms within *suites* of Group C *occupancy* shall be not more than 200.

Table 3.1.13.A.
Forming Part of Sentence 3.1.13.2.(1)

Occupancy, Location or Element	Maximum *Flame-Spread Rating* for Walls and Ceilings	
	Sprinklered	Unsprinklered
Group A, Division 1 *occupancies*, including doors, skylights, glazing and light diffusers and lenses	150	75
Group B *occupancies*	150	75
Exits[1]	25	25
Lobbies described in Sentence 3.4.4.2.(2)	25	25
Covered vehicular passageways, except for roof assemblies of *heavy timber construction* in such passageways	25	25
Vertical service spaces	25	25
Column 1	2	3

Note to Table 3.1.13.A.:
[1] See Articles 3.1.13.8. and 3.1.13.10.

3.1.13.4. Light Diffusers and Lenses

(1) The *flame-spread rating* of *combustible* light diffusers and lenses in all *occupancies* other than Group A, Division 1 *occupancies* is permitted to be more than the *flame-spread rating* limits required elsewhere in this Subsection provided the light diffusers and lenses

(a) have a *flame-spread rating* of not more than 250 and a smoke developed classification of not more than 600 when tested in conformance with CAN/ULC-S102.2-M, "Standard Method of Test for Surface Burning Characteristics of Flooring, Floor Covering, and Miscellaneous Materials and Assemblies,"

(b) fall to the bottom of the test apparatus before igniting when tested in conformance with ULC-S102.3-M, "Standard Method of Fire Test of Light Diffusers and Lenses,"

(c) are not prevented from falling from the ceiling by construction located beneath the elements, and

(d) are not used in corridors that are required to be separated from the remainder of the *building* by a *fire separation* or in *exit* shafts unless individual diffusers or lenses are not more than 1 m² in area and are not less than 1.2 m apart.

3.1.13.5. Skylights. Individual *combustible* skylights in corridors that are required to be separated from the remainder of the *building* by a *fire separation* shall be not more than 1 m² in area and not less than 1.2 m apart.

3.1.13.6. Corridors

(1) Except where the *building* is *sprinklered*, the interior wall finish of *public corridors*, corridors used by the public in *assembly* and *institutional occupancies* and corridors serving classrooms or sleeping rooms in *institutional occupancies*, including *occupancies* in such corridors, shall have a maximum *flame-spread rating* of not more than

(a) 75, or

(b) 25 on the upper half of the wall and 150 on the lower half of the wall.

(2) Except where the *building* is *sprinklered*, the interior ceiling finish of corridors and *occupancies* in Sentence (1) shall have a *flame-spread rating* of not more than 25.

3.1.13.7. High Buildings

(1) Except as permitted in Sentences (2) to (4), the interior wall, ceiling and floor finishes in a *building* regulated by the provisions of Subsection 3.2.6. shall conform to the *flame-spread rating* requirements in Article 3.1.13.2. and to the *flame-spread rating* and smoke developed classification values in Table 3.1.13.B.

(2) Except for *buildings* of Group B *major occupancy* and elevator cars, the *flame-spread rating*

Table 3.1.13.B
Forming Part of Sentence 3.1.13.7.(1)

Maximum Location or Element	Maximum *Flame-Spread Rating*			Maximum Smoke Developed Classification		
	Wall Surface	Ceiling Surface [1]	Floor Surface	Wall Surface	Ceiling Surface [1]	Floor Surface
Exit stairways, vestibules to *exit* stairs and lobbies described in Sentence 3.4.4.2.(2)	25	25	25	50	50	50
Corridors not within *suites*	—	—	300	100	50	500
Elevator cars and vestibules	25	25	300	100	100	300
Service spaces and *service rooms*	25	25	25	50	50	50
Other locations and elements	—	—	No limit	300	50	No limit
Column 1	2	3	4	5	6	7

Note to Table 3.1.13.B.:

[1] See Sentence 3.1.13.4.(1) for lighting elements.

and smoke developed classification of interior wall, floor and ceiling finishes need not conform to the values in Table 3.1.13.B. provided the *building* is *sprinklered* and the sprinkler system is electrically supervised in conformance with Sentence 3.2.6.4.(1).

(3) Trim and millwork in *exit* stairways, vestibules to *exit* stairways, lobbies described in Sentence 3.4.4.2.(2) and corridors not within *suites* need not conform to the *flame-spread rating* and smoke developed classification requirements in Sentence (1) provided

(a) they have a *flame-spread rating* of not more than 150 and a smoke developed classification of not more than 300, and

(b) their aggregate area is not more than 10 per cent of the area of the wall or ceiling on which they occur.

(4) Doors in *exit* stairways, vestibules to *exit* stairways, lobbies described in Sentence 3.4.4.2.(2) and corridors not within *suites* need not conform to the *flame-spread rating* and smoke developed classification requirements in Sentence (1) provided

(a) they have a *flame-spread rating* of not more than 200 and a smoke developed classification of not more than 300, and

(b) their aggregate area is not more than 10 per cent of the area of the wall in which they occur.

3.1.13.8. Noncombustible Construction

(1) In *buildings* required to be of *noncombustible construction*,

(a) the *flame-spread ratings* in Subsection 3.1.5. shall apply in addition to the requirements in this Subsection, and

(b) the *flame-spread ratings* for *exits* in this Subsection shall also apply to any surface in the *exit* that would be exposed by cutting through the material in any direction, except that this requirement does not apply to doors, *heavy timber construction* in *sprinklered buildings* and *fire-retardant treated wood*.

3.1.13.9. Underground Walkways. Except for paint, the interior wall and ceiling finishes of an underground *walkway* shall be of *noncombustible* materials.

3.1.13.10. Exterior Exit Passageway. Where an exterior *exit* passageway provides the only *means of egress* from the rooms or *suites* it serves, the wall and ceiling finishes of that passageway, including the soffit beneath and the *guard* on the passageway, shall have a *flame-spread rating* of not more than 25, except that a *flame-spread rating* of not more than 150 is permitted for up to 10 per cent of the total wall area and for up to 10 per cent of the total ceiling area.

3.1.14. Roof Assemblies

3.1.14.1. Fire-Retardant Treated Wood Roof Systems

(1) Where a *fire-retardant treated wood* roof system is used to comply with the requirements of Subsection 3.2.2., the roof deck assembly shall meet the conditions of acceptance of CAN/ULC-S126-M, "Standard Method of Test for Fire Spread Under Roof-Deck Assemblies."

(2) Supports for the roof deck assembly referred to in Sentence (1) shall consist of

(a) *fire-retardant treated wood*,

(b) *heavy timber construction*,

(c) *noncombustible construction*, or

(d) a combination thereof.

3.1.14.2. Metal Roof Deck Assemblies

(1) Except as permitted in Sentence (2), a metal roof deck assembly shall meet the conditions of acceptance of CAN/ULC S126-M, "Standard Method of Test for Fire Spread Under Roof-Deck Assemblies" if

(a) it supports a *combustible* material above the deck that could propagate a fire beneath the roof deck assembly, and

(b) the deck is used to comply with the requirements for *noncombustible construction* in Sentences 3.2.2.16.(2), 3.2.2.17.(2), 3.2.2.21.(2), 3.2.2.25.(2), 3.2.2.31.(2), 3.2.2.40.(2), 3.2.2.41.(2), 3.2.2.42.(2), 3.2.2.44.(2), 3.2.2.52.(2), 3.2.2.57.(2), 3.2.2.58.(2) or 3.2.2.59.(2).

(2) The requirements of Sentence (1) are waived provided

(a) the *combustible* material above the roof deck is protected by a thermal barrier

October 30, 1990

TO: J. Ho
Adhesives and Sealants

REPORT NUMBER: P&C 38-90-69-30992-98

IDENTIFICATION: W.O. #41478

SPECIFICATIONS OF ORDER: Testing of Submitted Samples in Carbon Arc Weather-o-meter

---

INTRODUCTION

Four samples of which three had three specimens and one had one specimen were submitted for Weather-o-meter testing. The samples were to be tested in accordance with ASTM G23 for 168 hours. The samples were identified as follows:

Client Identification	ORTECH Sample Number
Yellow colour	90-69-C0080-1
Yellow colour	90-69-C0080-2
Yellow colour	90-69-C0080-3

Natural colour P129	90-69-C0081-1
Natural colour P129	90-69-C0081-2
Natural colour P129	90-69-C0081-3
Dark colour P129	90-69-C0082-1
Dark colour P129	90-69-C0082-2
Dark colour P129	90-69-C0082-3
Armstrong Tile	90-69-C0083

PROCEDURE

The samples were exposed for 168 hours in accordance with ASTM G23, Type D, Practice of Operating Light - and - Water -Exposure Apparatus.

(Carbon Arc Type) for Exposure of Nonmetallic Materials.

OBSERVATIONS

No observations were made, the exposed samples were returned to the client for observations.

Ben Zeeman
Project Technologist
Paints and Coatings

David M. Hacker
Manager
Coatings and Adhesives

October 31, 1990

To: Fred Law

REPORT NO.:	90-48-35000-039
IDENTIFICATION:	Work Order # 41534
SPECIFICATIONS OF ORDER:	Fungus resistance testing of sample according to ASTM G-21 without humidity control.

SUMMARY

The fungal resistance testing of the grey slab sample was conducted according to ASTM G-21 except that the high humidity conditions were maintained without continuous monitoring.

The sample supported fungal growth on all of the cut edge surfaces. The flat surface of the sample supported fungal growth only in patches near the cut edge of the sample. The sample was rated as a 2 according to ASTM G-21 rating scheme.

METHOD

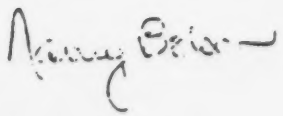
Fungus resistance testing according to a modified ASTM G-21 Method.

For ASTM G-21, five fungal cultures are used: Aspergillus niger (ATCC 9642), Penicillium funiculosum (ATCC 9644), Chaetomium globosum (ATCC 6205), Gliocladium virens (ATCC 9645) and Aureobasidium pullulans (ATCC 9348).

The cultures were harvested with a nutrient salts solution to prepare a mixed spore suspension. The stock cultures employed were less than four months old. The viability of each fungal culture was confirmed. Controls were prepared as described in ASTM G-21, inoculated and incubated with the test specimens. Inoculation of the test sample with the mixed five fungal spore suspension was accomplished by spraying the suspension in the form of a fine mist from an atomizer. The test item was sprayed on all surfaces until the initiation of droplet coalescence. The sample was placed on nutrient salts agar in a sterile pyrex dish. Incubation was at 28°C and high relative humidity for 21 days. Controls were observed at 7 and 13 days to confirm the mixed suspension's viability. The sample was rated according to ASTM G-21 "Observed Growth on Specimens" (reproduced as Table 1 of this report). Rating was performed on the 21st day using a stereoscopic binocular microscope.

RESULTS

The grey slab sample supported fungal growth on the cut edges of the sample. This growth was rated as a 2 according to the rating scheme in ASTM G-21 (i.e light growth 10 to 30% coverage).



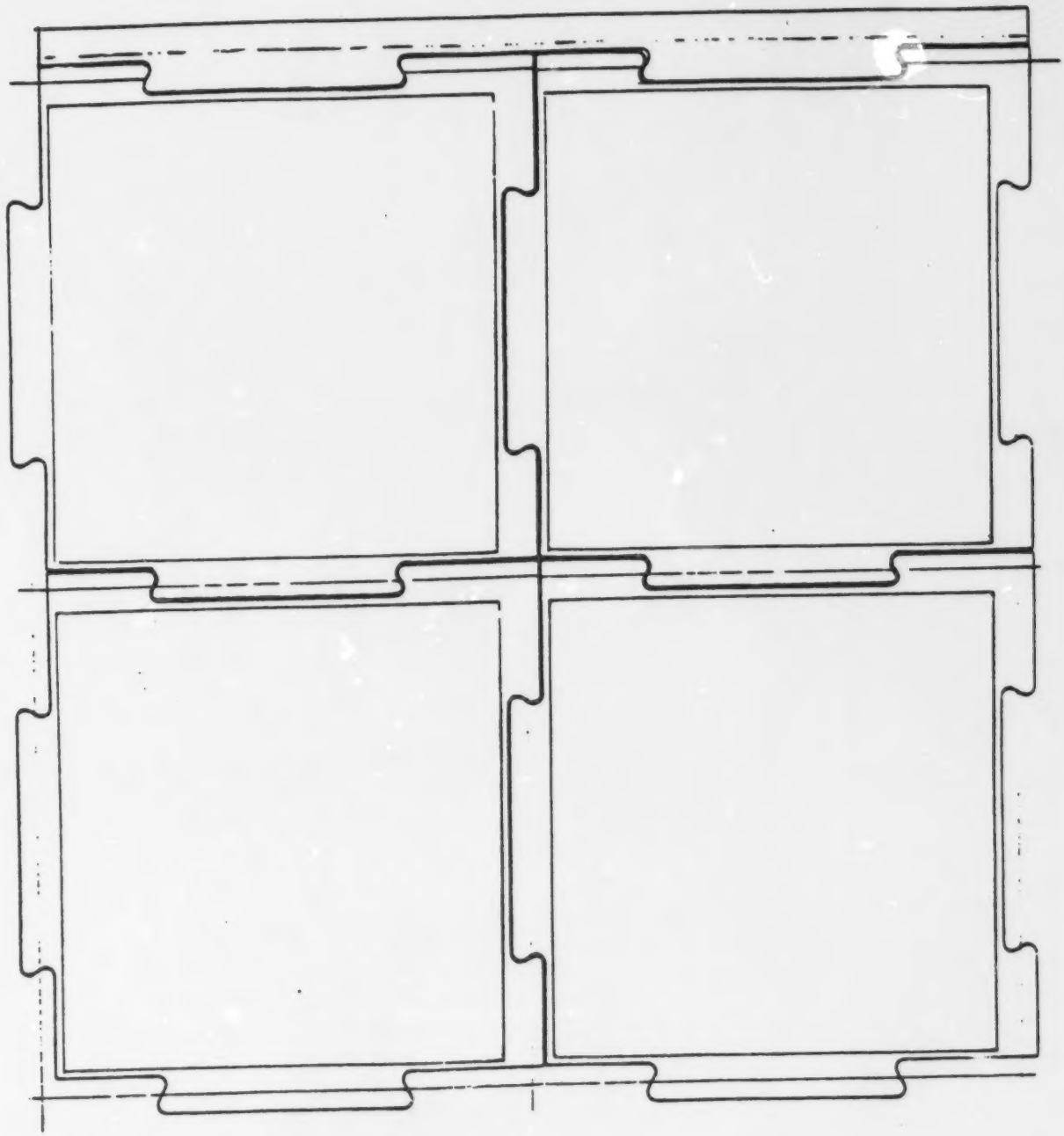
Nancy Belson, B.Sc.
Biological & Sensory Section
Biotechnology & Chemical Engineering Centre

TABLE 1

"Observed Growth on Specimens"
from ASTM G-21

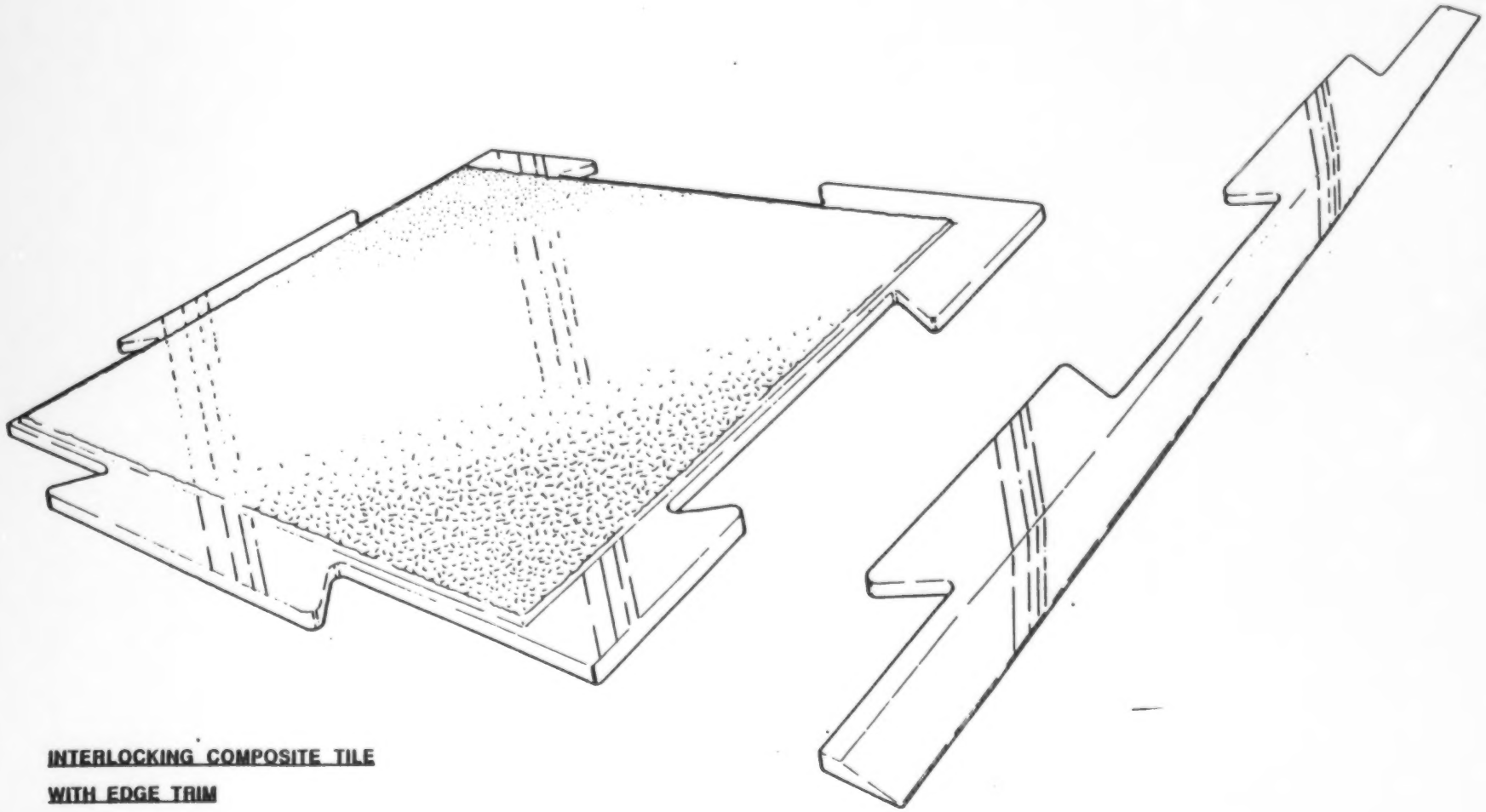
Observed Growth on Specimens	Rating
None	0
Traces of growth (less than 10%)	1
Light growth (10 to 30%)	2
Medium growth (30 to 60%)	3
Heavy growth (60% to complete coverage)	4

APPENDIX C: Product Design
(7 pages)



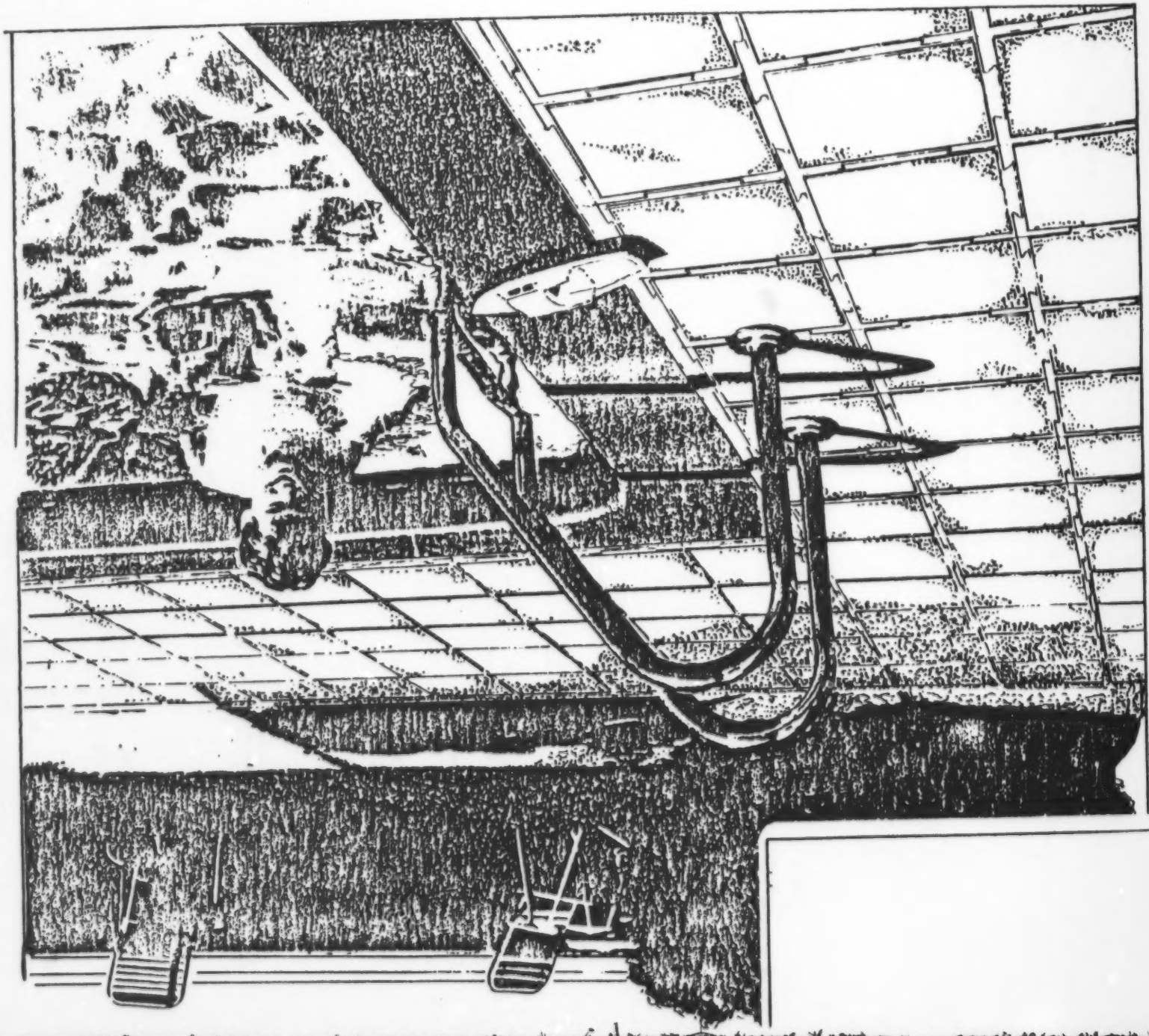
INTERLOCKED COMPOSITE TILE

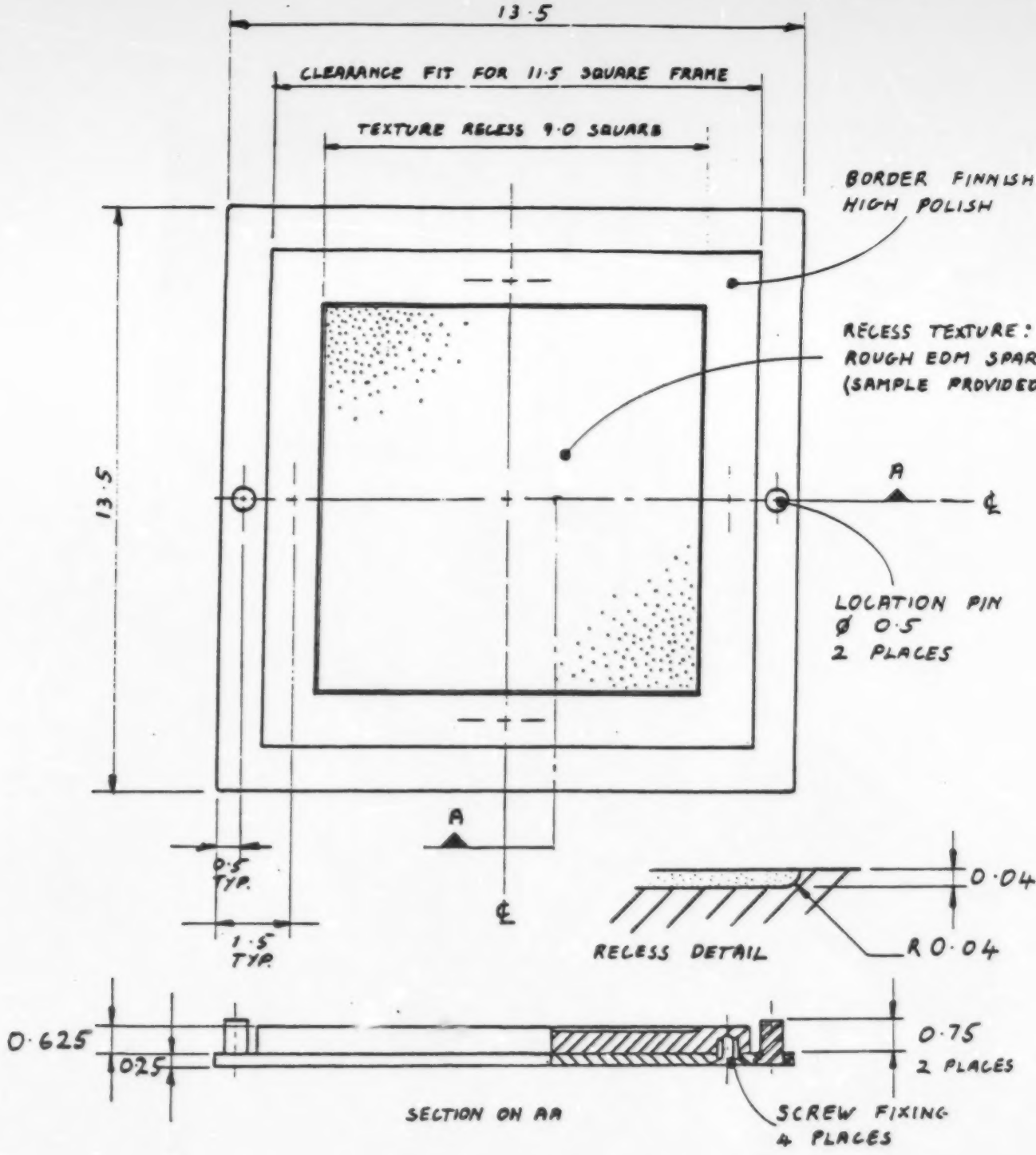
WITH EDGE TRIM



INTERLOCKING COMPOSITE TILE

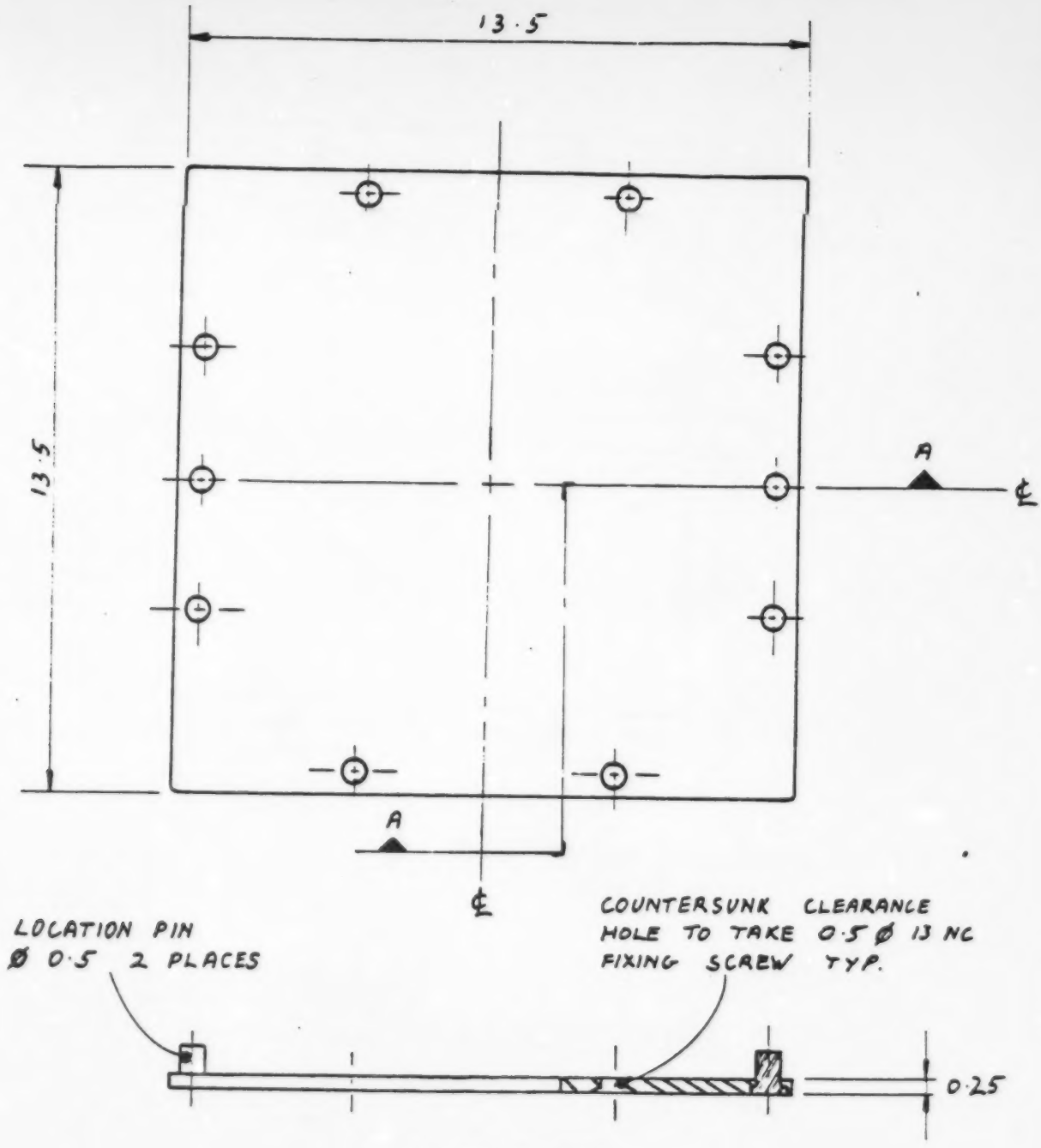
WITH EDGE TRIM





MATERIAL : STEEL
DIMENSIONS IN INCHES

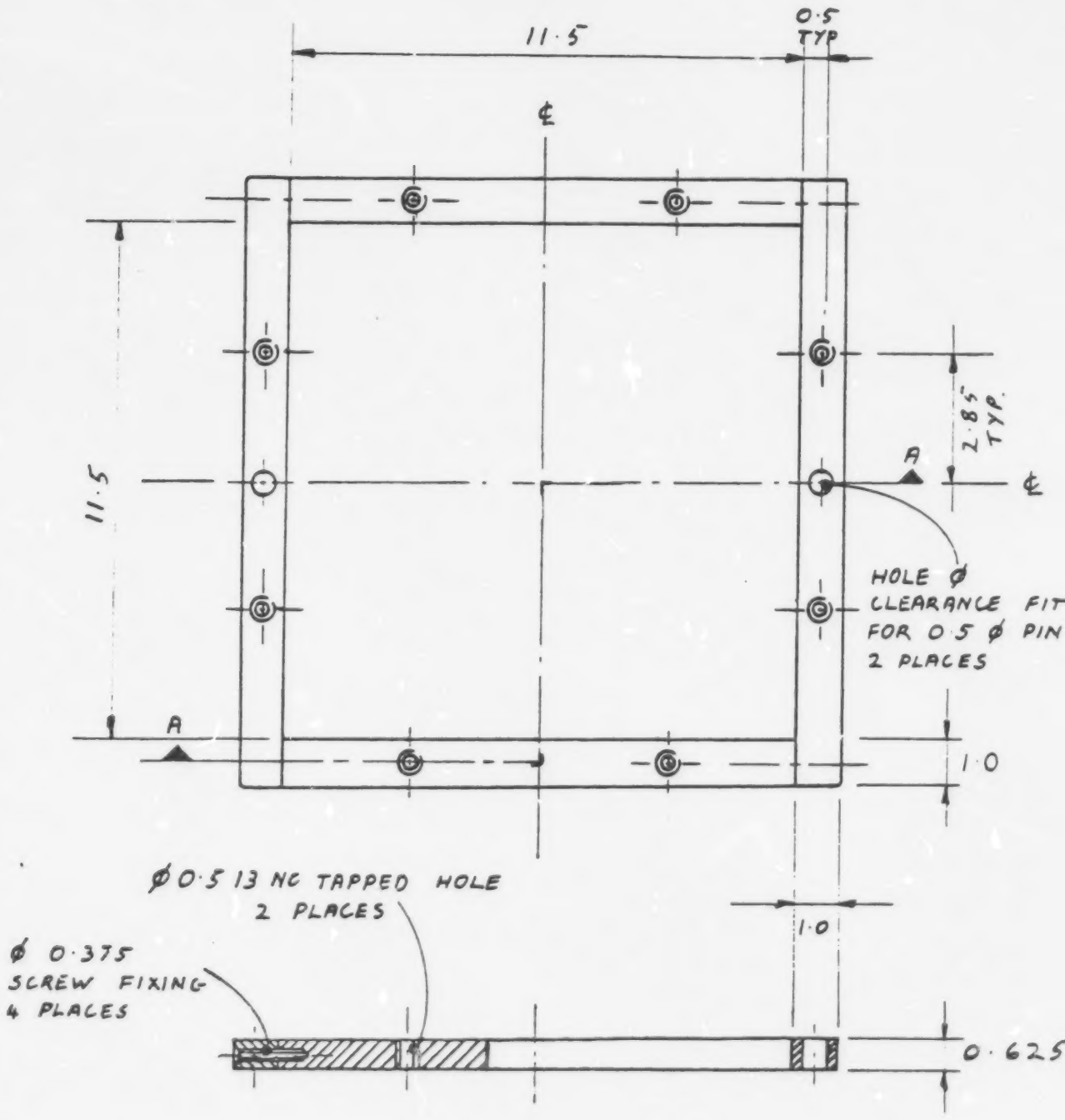
COMPRESSION MOULD TOOL
PLUG



SECTION ON AA

MATERIAL : STEEL
DIMENSIONS IN INCHES

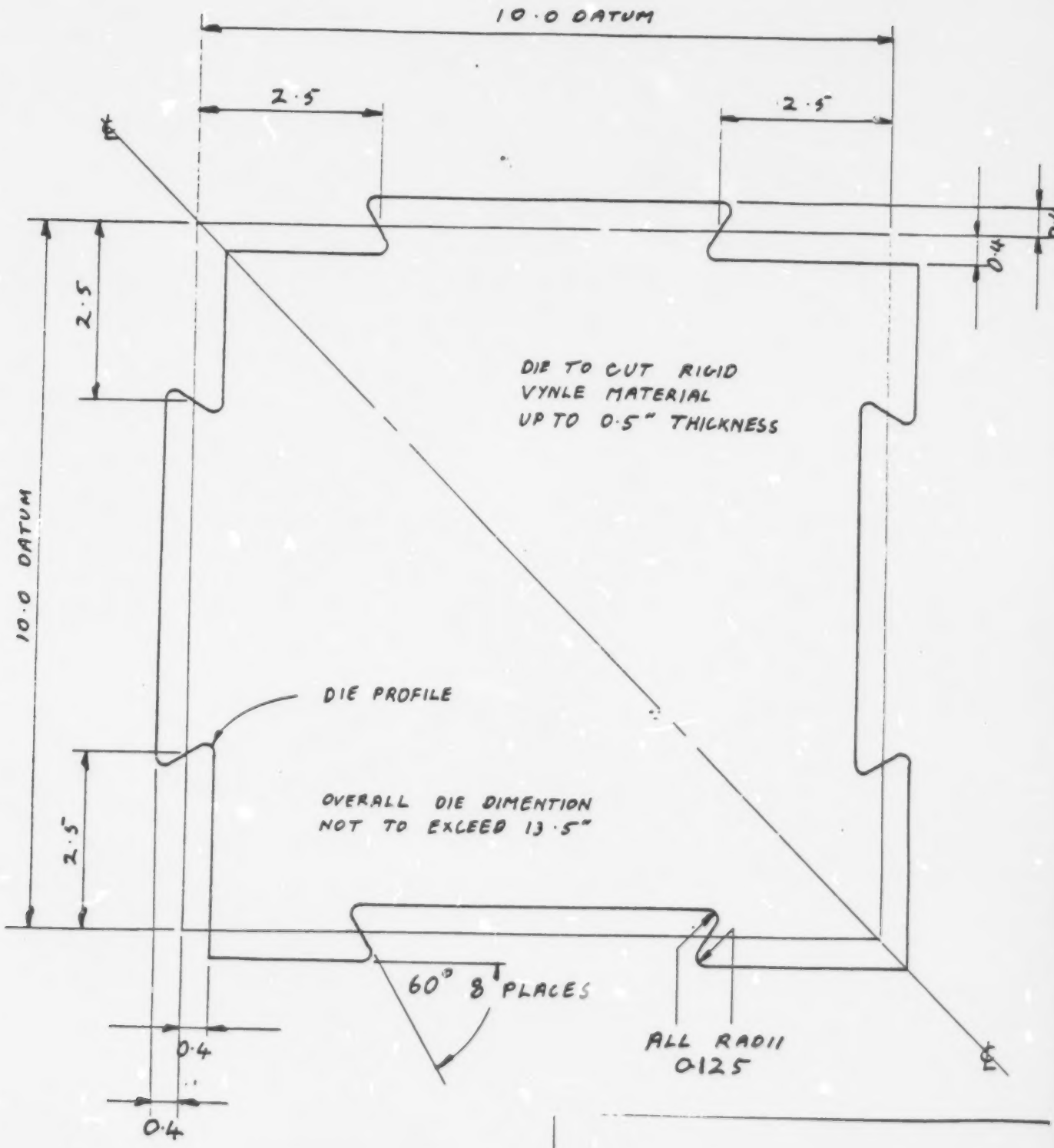
COMPRESSION MOULD TOOL
BASE



SECTION ON AA

MATERIAL : STEEL
DIMENSIONS IN INCHES

COMPRESSION MOULD TOOL
FRAME



COMPONENT SYMETRICAL ABOUT
DIAGONAL CENTRE LINE

DIMENSIONS IN INCHES

COMPRESSION MOULDED TILE
DIE CUTTING PROFILE

APPENDIX D: Moulding of Prototypes
(2 pages - {Photographs)

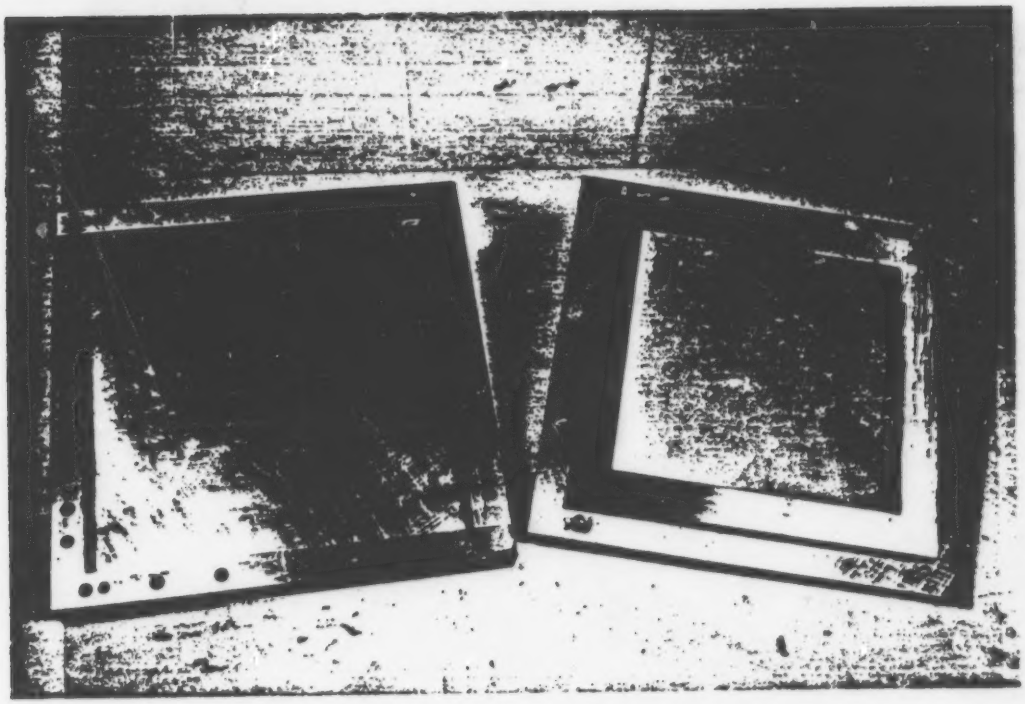


Photo 2: The 11.5 x 11.5 x 1/4 inch Compression Mould

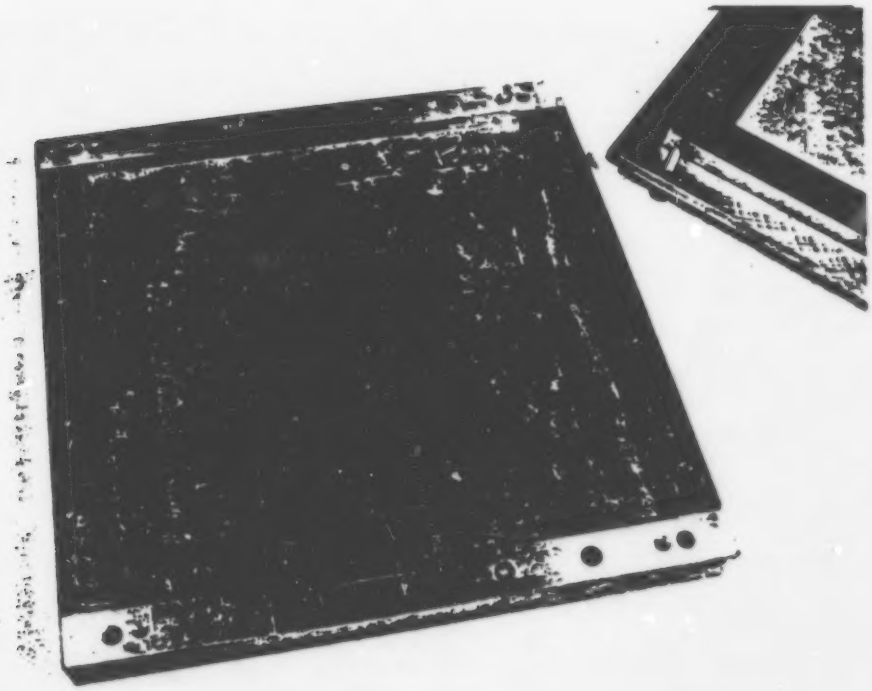


Photo 3: The semi-finished Floor Tile in the Compression Mould

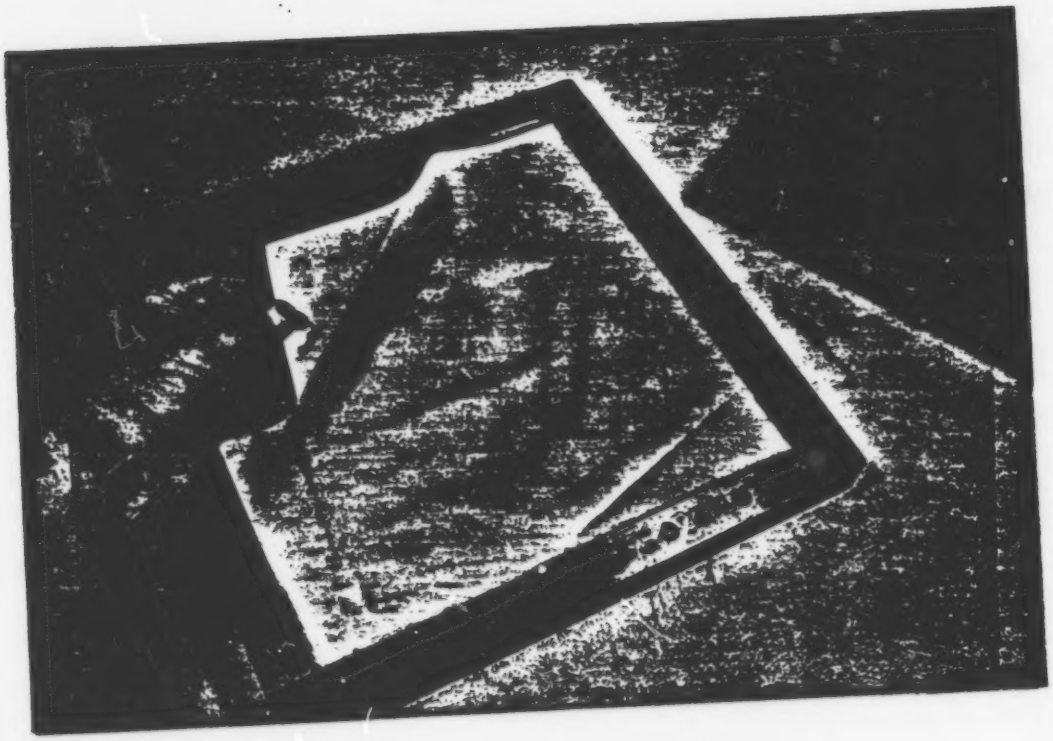


Photo 4: A PVC Facing Layer Was Put Into Place

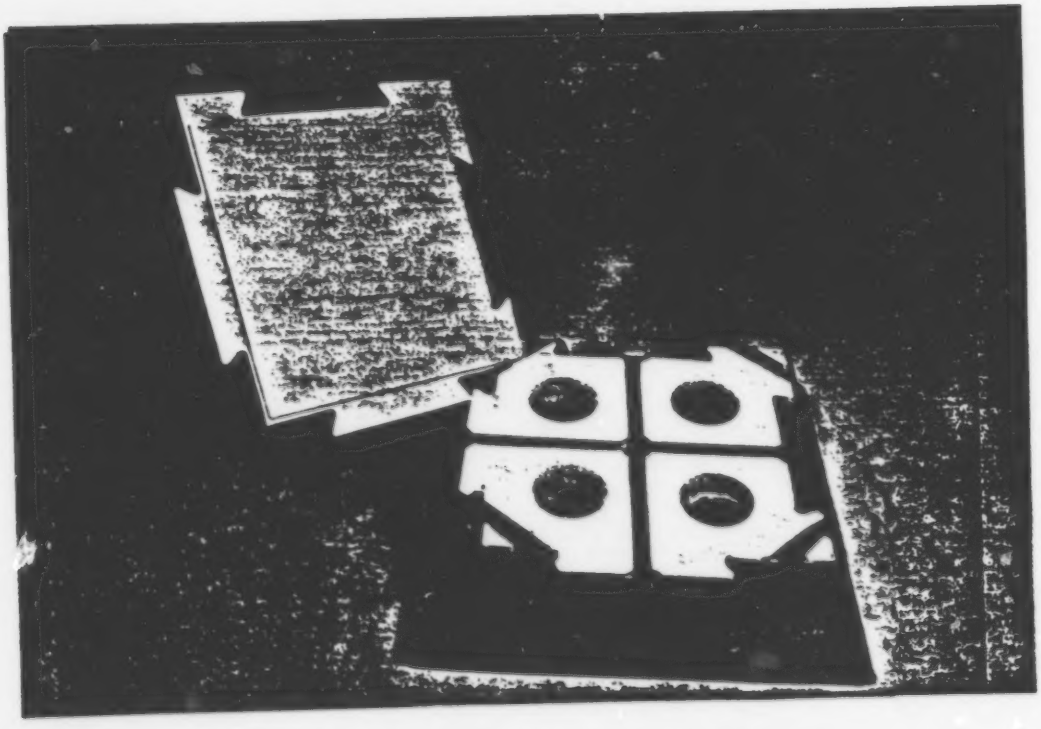


Photo 5: Die and Floor Tile With Interlocking Feature